Influence of Root Growth, Development, and Function on Horticultural Crop Productivity and Quality

ARS LOCATION:
Horticultural Crops Research Laboratory
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PROJECT OBJECTIVES:
1. Determine nutrient requirements to enhance product quality in woody perennial crops such as grapevine and rhododendron.
2. Characterize the role of mycorrhizal taxonomic diversity and identify important root-mycorrhizal interactions in cropping systems.
3. Enhance product quality by optimizing crop management practices that promote overall root function to satisfy nutrient requirements in woody perennial crops.

MAJOR ACCOMPLISHMENTS (2007 – 2010) (GRAPE ONLY):

Native Symbiotic Fungi not required for best Growth of Grapes:

Growth and nutrient uptake of grapevines is markedly improved by arbuscular mycorrhizal fungi (AMF) in red hill soils independent of AMF origin. While grapevines are generally known to benefit from associations with AMF, it is not known to what extent this benefit is influenced by soil type or the origin of the fungi that colonize roots. Researchers at the Horticultural Crops Research Laboratory demonstrated that grapevines grown in a red hill soil were exceptionally dependent on AMF to supply enough phosphorus (P) for growth, while vines grown in a more fertile valley soil can acquire enough P for normal vegetative growth without AMF. Grapevine growth response and P uptake was not better when a native fungus was compared to a nonnative fungus. Results indicate that grapevines planted on sites with red hill soils absolutely require AMF, but growers can be less concerned about AMF when planting vines in valley soils. The use of AMF that are native to a particular soil is not a critical factor for vine establishment. This information will aid wine grape growers and extension viticulturists to develop soil management strategies that enhance mycorrhizal establishment and function in vineyard systems.

Fungal Symbionts of Grapevine Roots Demystified: Diversity of arbuscular mycorrhizal fungi:

AMF in 'Pinot noir' roots is seasonally stable, but altered by soil type and vine age. Virtually nothing is known about the identity (and hence the functional diversity) of AMF that are engaged in symbiosis with grapevines in production vineyards. As a first step in understanding this functional diversity, researchers at the Horticultural Crops Research Laboratory compared the diversity of AMF amplified from 'Pinot noir' roots. A survey of 10 commercial vineyards revealed that grapevines were usually colonized by at least eight different AMF, and that four fungi were always found in grape roots. The community of fungi in roots did not change over the growing season, but differed between soil types (alluvial versus hill soils) and as vines aged. This information

provides the basis for researchers to characterize the functional roles of specific, indigenous AMF to enhance plant tolerance to nutrient and water stress and will aid in the development of soil management strategies that enhance mycorrhizal establishment and function in vineyard systems.

Grapevines Rely more Heavily on Fungal Symbionts under Water Stress:
Colonization of roots by AMF is enhanced by reduced irrigation. Regulated deficit irrigation (RDI) is used in irrigated vineyards to control canopy growth and improve fruit quality, but little is known about how imposed deficits alter root growth and beneficial mycorrhizal symbionts. ARS researchers at the Horticultural Crops Research Laboratory in Corvallis, Oregon, and industry collaborators investigated the impact of three irrigation regimes (standard RDI, 50 percent of RDI applied either before or after veraison to 'Cabernet Sauvignon' grapevines) on fine root production and AMF colonization of roots over a 3-year period. Fine root growth was reduced by both 50 percent RDI treatments, but this was countered by increased colonization of roots by AMF. Irrigation did not affect yield or quality of grapes produced, even though whole plant photosynthesis was reduced in both 50 percent RDI treatments. These results indicate that high quality grapes can be produced with less water than the current RDI practice because of greater colonization by symbiotic fungi at lower irrigation levels.

Foliar Phosphorus is Ineffective for Grapevines:
Foliar applications of phosphorus (P) fertilizer in vineyards of low P status have little impact on vine physiology or fruit quality. Foliar application of P fertilizers is a common practice in western Oregon vineyards; however, the effects of increased plant P status on mycorrhizal (AMF) colonization and plant growth are not well understood. The effect of foliar P fertilizers on 'Pinot noir' growth, nutrient status, AMF colonization, drought stress, and fruit quality was studied at two sites in western Oregon by ARS researchers at the Horticultural Crops Research Laboratory in cooperation with industry collaborators. Foliar P applications over 3 years slightly reduced AMF colonization, and slightly increased leaf or petiole P concentrations, but effects were not consistent within or between years or sites. Foliar P applications had no effect on growth, yield, fruit quality, or drought stress of vines. These results indicate that there is little benefit to applying P fertilizers, even in low P vineyards and that potential risk of P runoff (ground water contamination) or reduced AMF function appears to outweigh any benefits of using foliar P. Findings from this study provide the basis to eliminate application of foliar P fertilizers in vineyards, thus increasing profitability and reducing environmental impact.

Ring Nematodes Overcome Resistance in Grapevine Rootstocks:
The ring nematode is a common vineyard pest worldwide, where it can reduce vine establishment and crop yields. The most cost-effective means to maintain vine productivity in nematode-infested soils is to plant vines on nematode-resistant rootstocks. ARS scientists at Corvallis, Oregon showed that ring nematodes eventually reached high populations on root systems of vines grafted onto two rootstocks (101-14, 110R) that were previously found to be resistant in greenhouse trials. Of six

rootstocks tested, only 420A remained highly resistant to ring nematode after 4 years in field microplots. These findings are particularly important for viticulturists in the Pacific Northwest, since 101-14 is a common rootstock used in the region.

Alleyway Cover Crops Have Minimal Impact on Grape Production:
Cover crop use in vineyards has been implicated to compete with grapevines for nutrients or water, thereby limiting vine growth or productivity. ARS and Oregon State University researchers investigated whether or not various cover crops grown in vineyard alleys (but not under vines) and managed by mowing in spring and summer in western Oregon would compete with the grapevines for nutrients or water. Five different cover crop mixtures were compared to a clean-cultivated control and resident vegetation treatments over 2 years at two sites. Cover crop treatments had an impact on grapevine N status at one vineyard; altering leaf blade N concentrations at bloom and juice N concentrations at harvest, although different treatments did not alter N status consistently over time. Cover crops did not alter shoot growth, pruning mass, leaf water potential, fine root density or colonization of roots by AMF; nor did cover crops affect yield, cluster weights, juice soluble solids, pH, or titratable acidity. Our data show that alleyway cover crops managed by spring and summer mowing do not have consistent effects on grapevines in western Oregon vineyards, and suggests that little competition occurs between cover crops and vines.

Balancing Nutrient Supply for Productivity and Quality of Grapes:
Low nitrogen (N) supply to 'Pinot noir' increases berry flavor volatiles, but decreases yield and berry YAN (yeast available nitrogen). N is likely the most important nutrient to manage in grapevine production, as it alters canopy and berry growth and influences the light environment around developing fruit clusters. Grape growers in western Oregon and Washington are interested in using low N supply to control canopy growth since vine access to soil water is not limiting early in the growing season. ARS and Oregon State University researchers in Corvallis, Oregon, and ARS researchers in Parma, Idaho, discovered that reducing N supply to grapevines grown in a sand-culture vineyard can increase the concentrations of certain flavor constituents (including monoterpenes and norisoprenoids) and color compounds (anthocyanins) in berries, but these positive effects on berry quality due to low N supply were not realized until crop yield, photosynthesis, and berry YAN were below acceptable levels. These results indicate that using low N supply as a tool to reduce vigor and improve berry quality parameters will not be effective or sustainable in the rain fed areas of the Pacific Northwest. Results from this research will help grape growers produce quality fruit without adversely affecting vine productivity and health and provide baseline data to refine tissue nutrient standards for regional winegrapes.

TECHNOLOGY TRANSFER/OUTREACH:

- Numerous presentations at scientific/commodity meetings and field days.
- Co-developed an online teaching & resource module for managing grapevine nutrition.

EXTERNAL SUPPORT:
Viticulture Consortium West; Oregon Wine Board; Northwest Center for Small Fruits Research; and National Science Foundation.

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RECENT PUBLICATIONS:

- Schreiner, R. P. (2010) Foliar application of phosphorus has minimal impact on 'Pinot noir' growth, mycorrhizal colonization, or fruit quality. HortScience 45:815-821.
- Sweet, R. M. and Schreiner, R. P. (2010) Alleyway cover crops have little influence on Pinot noir grapevines (Vitis vinifera L.) in two western Oregon vineyards. American Journal of Enology and Viticulture 61:240-252.
- Lee, J. and Schreiner, R.P. (2010) Free amino acid profiles from 'Pinot noir' grapes are influenced by vine N-status and sample preparation method. Food Chemistry 119:484-489.
- Schreiner, R. P. and Mihara K. L. (2009) The diversity of arbuscular mycorrhizal fungi amplified from grapevine roots (Vitis vinifera L.) in Oregon vineyards is seasonally stable and influenced by soil and vine age. Mycologia 101:599-611.
- Schreiner, R. P. and Pinkerton, J. N. (2008) Ring nematodes (*Mesocriconema xenoplax*) alter root colonization and function of arbuscular mycorrhizal fungi in grape roots in a low P soil. *Soil Biology & Biochemistry* 40:1870-1877.
- Pinkerton, J. N., Kraus, J. , Martin, R. R., and Schreiner, R. P. (2008) Epidemiology of *Xiphinema americanum* and *Tomato ringspot virus* on Red raspberry, *Rubus idaeus*. *Plant Disease* 92:364-371.
- Schreiner, R. P., Tarara, J. M. and Smithyman R. (2007) Deficit irrigation promotes arbuscular colonization of fine roots by mycorrhizal fungi in grapevines (*Vitis vinifera* L.) in an arid climate. *Mycorrhiza* 17:551-562.
- Schreiner, R. P. (2007) Effects of native and nonnative arbuscular mycorrhizal fungi on growth and nutrient uptake of 'Pinot noir' (*Vitis vinifera* L.) in two soils with contrasting levels of phosphorus. *Applied Soil Ecology* 36:205-215.